Crossbow Technology

Smarter Sensors In Silicon

DARPA SensIT

- Company History and Overview

- Mote Status

January 17, 2002

Crossbow
INTELLIGENT Sensors
CrossNet WIRELESS

Corporate Overview

- Founded by Mike Horton and A. Richard Newton in 1995
  - » Headquarters in San Jose, CA.
  - » Founders instrumental in MEMS technology at UC – Berkeley
- Board of Directors
  - » Jerry L. Fiddler, Founder/Chair, Wind River Systems
  - » Harvey C. Jones, Chairman, Tensilica; Former CEO Synopsys
  - » Paul L. Davies III - Managing Principal, Cambria Group
  - » A. Richard Newton - Dean Engineering, UC Berkeley
  - » Michael A. Horton - Co-founder, Crossbow President/CEO
- Lead Venture Investor: Morgenthaler Ventures

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Crossbow Today

- 40 employees – San Jose CA
- Intelligent Sensors Products:
  - » Accelerometers, Tilt Sensors, Magnetometers, IMUs, Vertical Gyros, AHRS.
  - » 100,000 intelligent sensors installed in a variety of markets
- Wireless Sensor Networks:
  - » Sensor-Independent Wireless DAQ Kits—Bluetooth-Based
  - » Berkeley “Motes” Wireless Sensor Networks
- Named to Top 50 Companies To Watch: Cahners Electronics Industry’s Movers & Shakers 2000
- Two “Best Products” awards for 2001 in Sensors Magazine for Inertial and Wireless products

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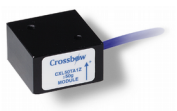
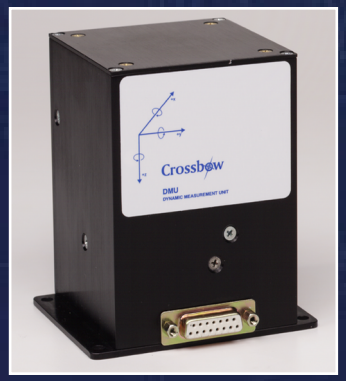
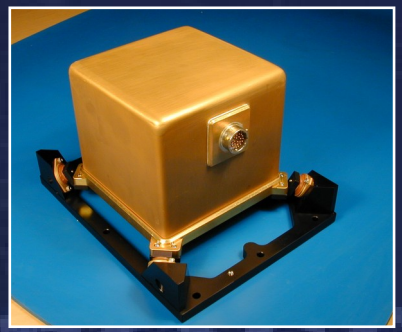
Crossbow Standard Products

ProductLine	Applications	Markets
Inertial/Gyro	• Navigation • Stabilization	• Aerospace • Military • Marine
Acceleration 	• Machine Health • Vibration Testing • General Purpose	• Factory Automation • Automotive • Smart Munitions
Tilt	• Machine Control • Machine Safety	• Construction • Heavy Equipment
Magnetic	• Navigation	• Drilling • Scientific Instrumentation
Wireless	• Data Collection • Automation	• Vehicle Testing • Process Control

Inertial Products

- In 1998 Crossbow introduced the first all silicon based Inertial Measurement Unit (IMU).





Traditional Inertial Markets

Results:

- Captured design wins with top companies in existing aerospace/military market. Replaced outdated technology with improved performance/cost ratio.

NORTHROP GRUMMAN

Raytheon

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New Inertial Applications

Results:

- Enabled new markets:
  - » Major partnerships in General Aviation, Automated Farming
  - » Precision guided municipal vehicles, construction equipment

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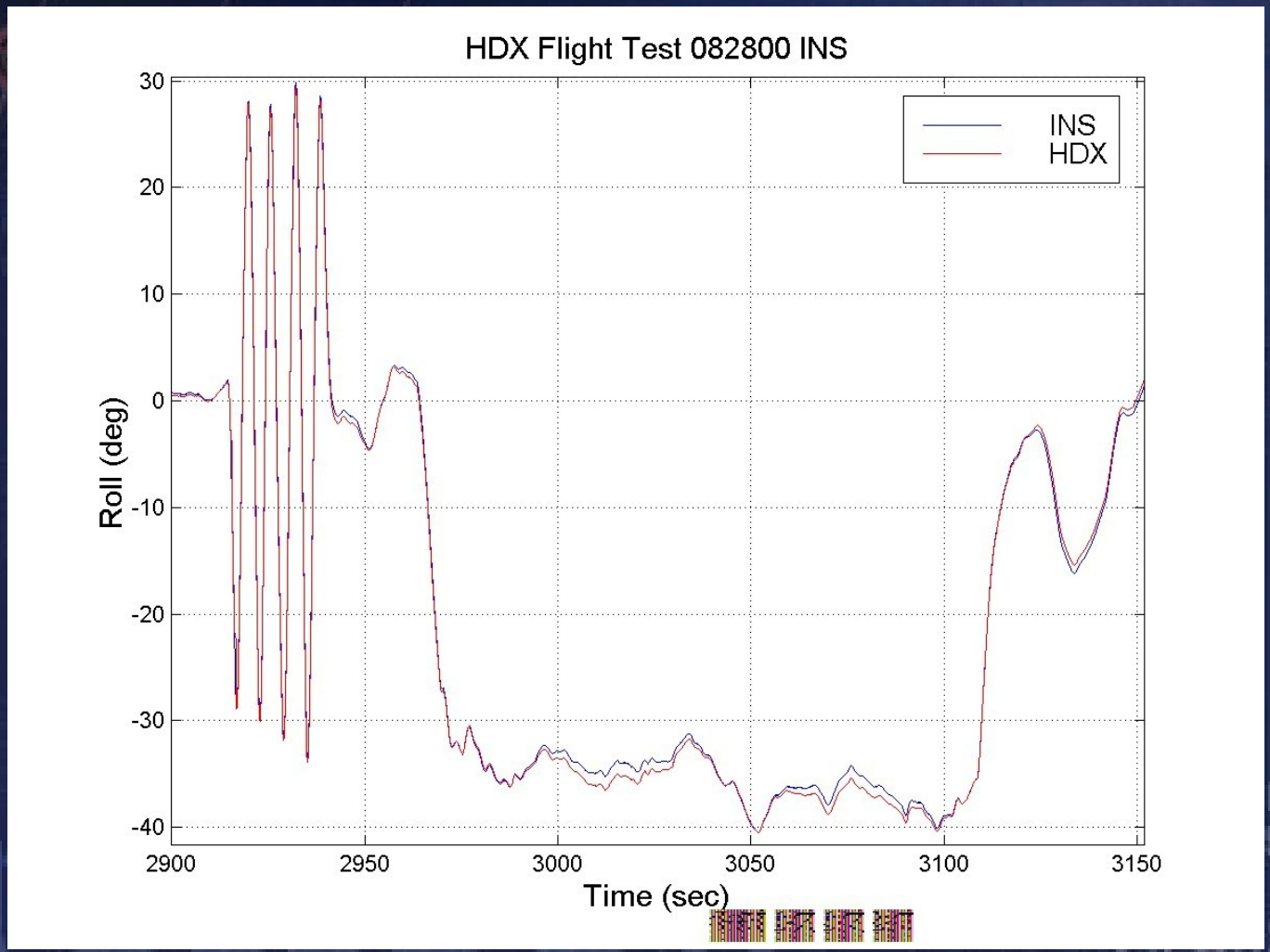
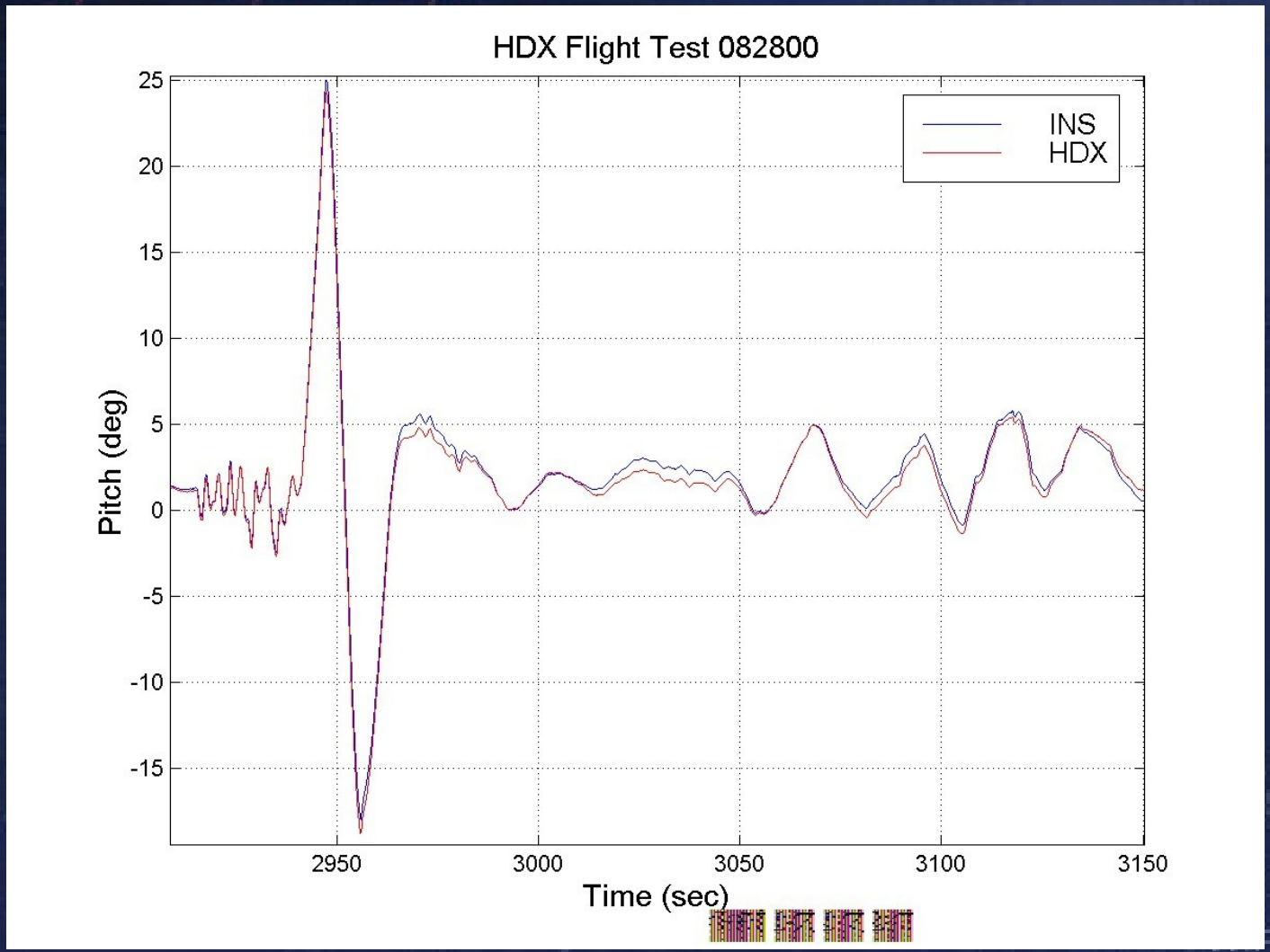
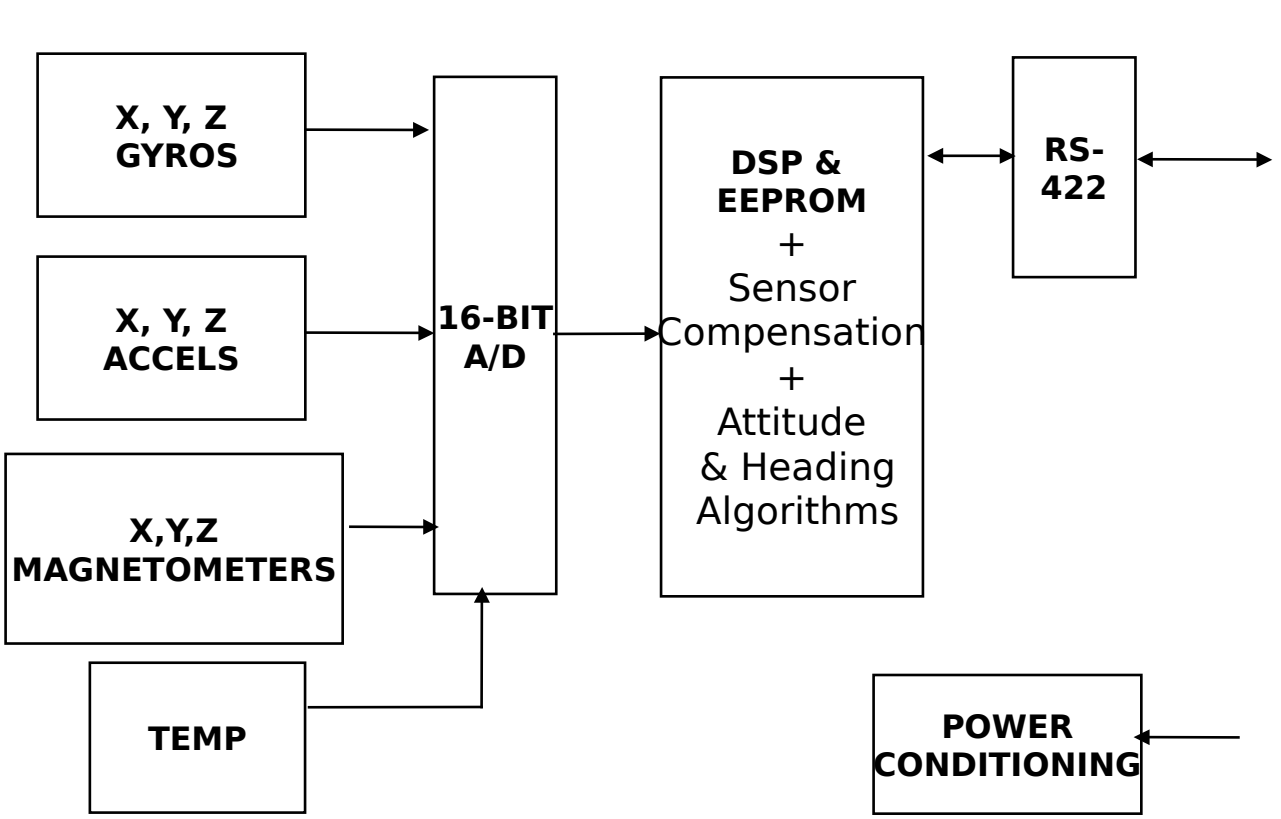
Performance
High Dynamic Profile--Roll



Performance:
High Dynamic Profile--Pitch

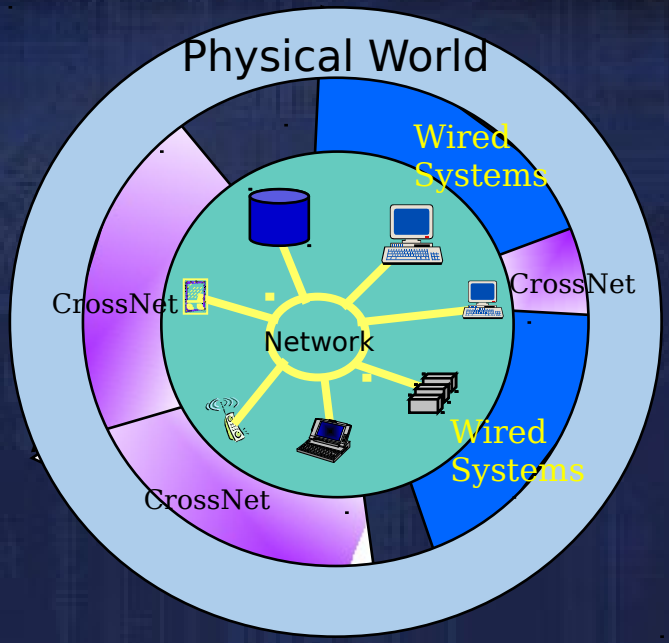


Crossbow Inertial Architecture



Wireless Sensor Networks

- **Fill The Gap**
  - » Growing requirements for easy sensing and measurements
  - » New computing and communications infrastructure (wireless, internet)
  - » *Provide new, simple, wireless linkage between the physical world and the computer*



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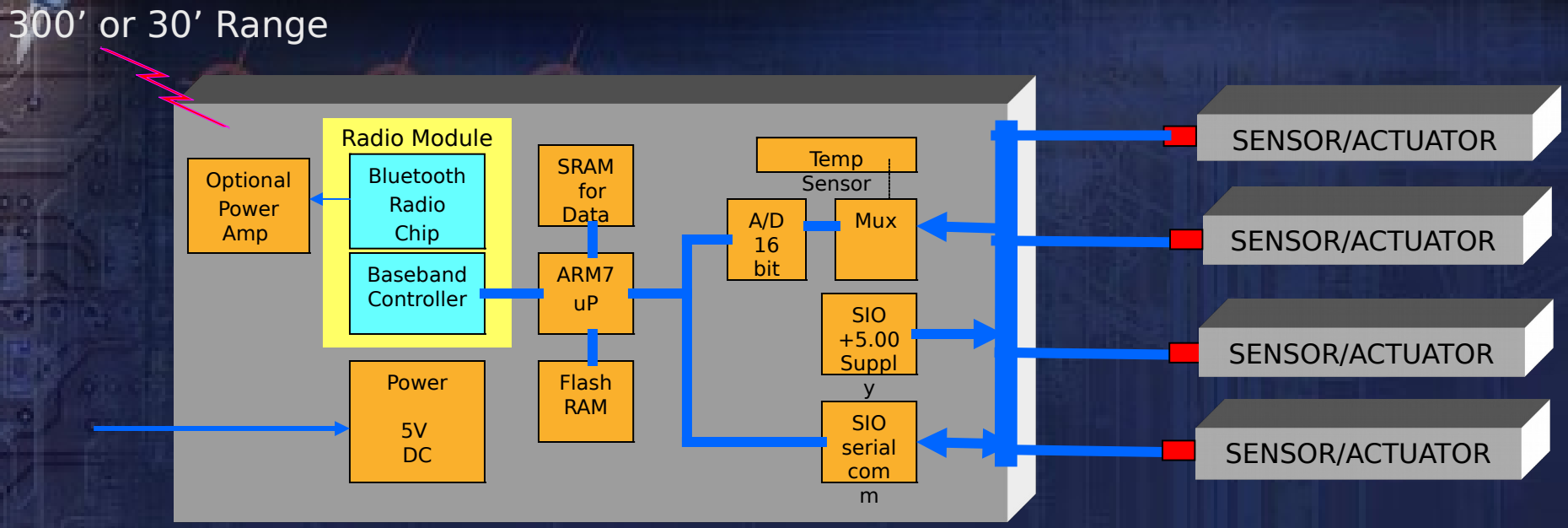
Wireless Node Architecture



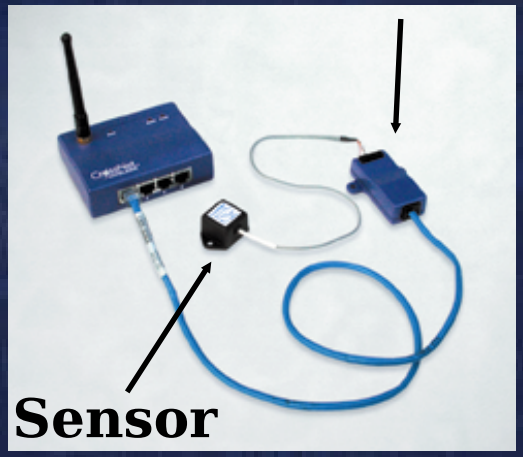
- Wireless “plug and play” of analog sensors to digital networks
- Integrates Bluetooth and open interface standards with Crossbow sensor IP
- Local computing, control, and signal conditioning

General DAQ Network

Smart I/O

Node

Hub:
PC Radio



- Target Markets: General Purpose Data Acquisition and Data Logging, Lab Environments
- Easily links existing sensors wirelessly to your PC
- 4 channel, 100m range
- Receive data on your PC using Crossbow's software
- Available now

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Markets for Wireless Sensor Networks

- Major Potential Markets:
  - » Military
  - » Machine Health Monitoring
  - » Food Storage
  - » Factory Automation
  - » Plant Automation
  - » Building Automation
  - » Automotive
  - » Security
  - » Utilities

All of these industries looking at wireless technologies.

Most are slow to adopt. Very early stages. Will be a long time before wholesale shift.

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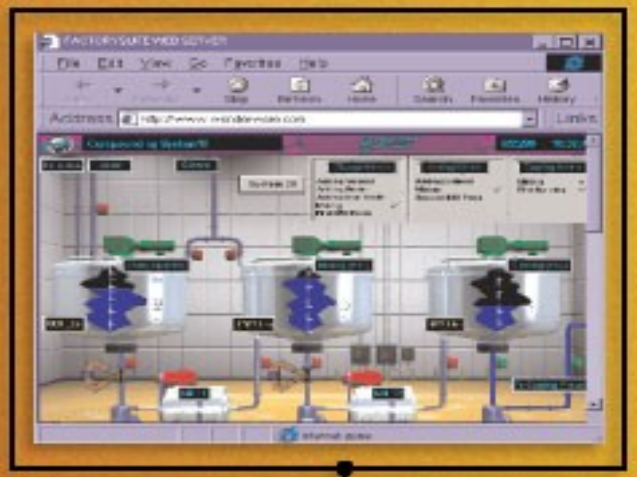
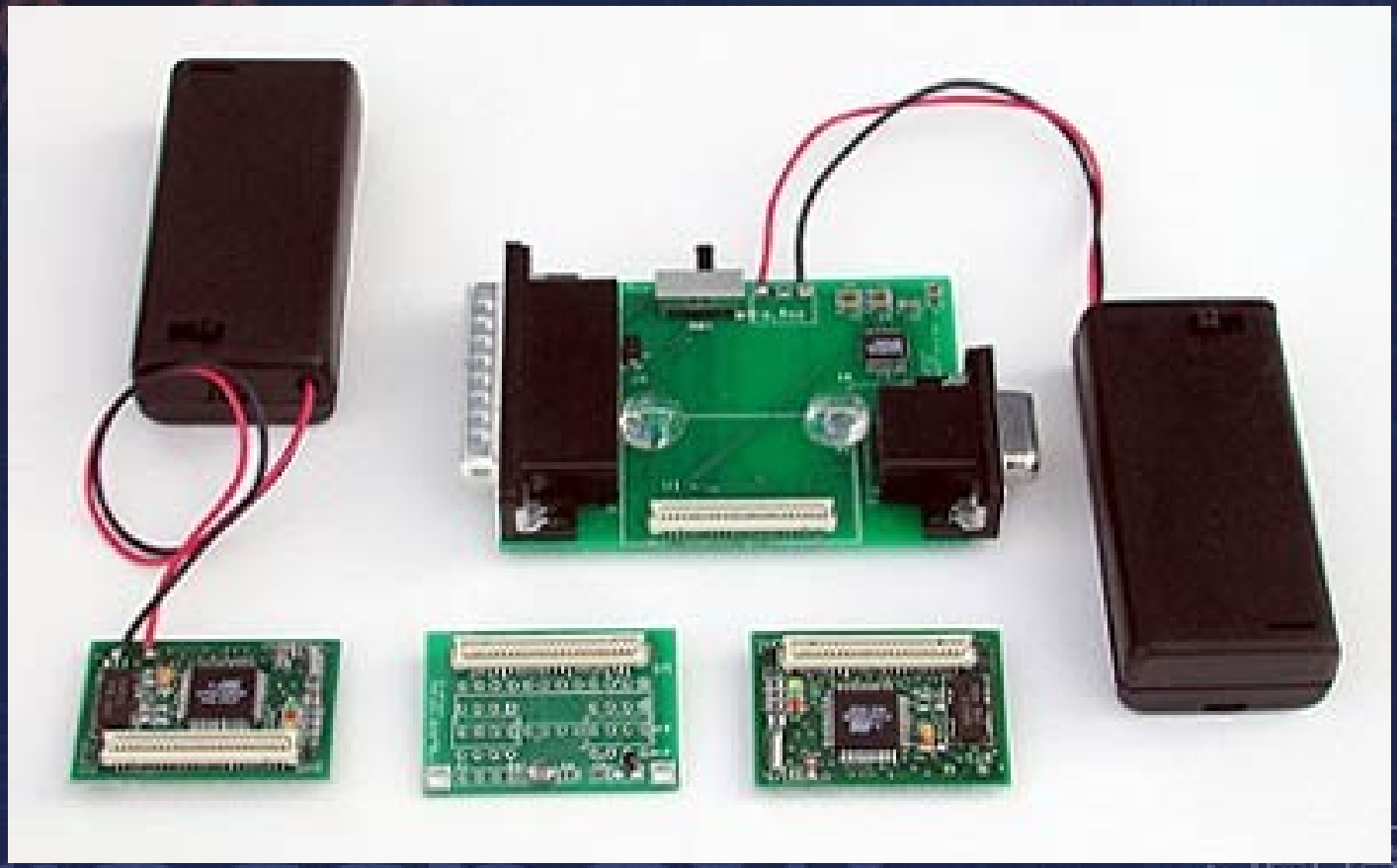
Wireless Industrial Application Sensing/Actuation—I/F with Ctrl System



Collaboration with UC Berkeley MOTES!



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Crossbow Collaboration with UCB on Rene Mote

- Provide Berkeley-designed wireless ‘motes’ to research community
- Seismic and Building Monitoring—Joint with UCB (EECS/CE)
  - » Deployed Network for energy monitoring—Cory Hall
  - » Deployed Network in Japanese Earthquake Study
  - » Instrumented 3-Story Building on Seismic shaker—Richmond
- Military-Use Wireless Sensor Network
  - » UCB / DARPA; deploy for various detection missions.

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MICA Motes

	Rene	MICA
Processor	4MHz	4MHz
Memory	16K	128kbytes
Antenna	add-on external	on-board antenna
		optional external
Radio	RFM 916MHz	RFM 916MHz
Speed	19.2Kbaud	52Kbaud
On-Board Flash	256K-bit	4M-bit
Unique ID	No	Yes

- Radio/Processor Board and PC I/F Board: Delivery March 1
- Old Light/Temp Sensor Board Compatible: Available Now
- New Sensor Board: Light, Temp, Mag, Accel, Acoustic
  - Two Versions: Fully loaded and sparsely populated
  - Probably March 15

Crossbow Mote Improvement Initiatives

- Power Management (in software)—designed
- Improved manufacturability
- Incorporate better radio technologies:
  - » robustness to interference (spread spectrum or tunable)
  - » range / power
- Better software support and documentation
- Targeted solutions, e.g., seismic, personnel detection
- ***There is no "one-size-fits-all" architecture.***
  - » ***The application drives the requirements***

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Crossbow Summary

- Market leader and innovator in Intelligent Sensors
- Market leader in MEMS-based Inertial systems
  - » UAVs, ROVs, Land vehicles, automotive test, and now General Aviation
- Strong background in qualification to Mil-std environmental and other specifications
- Initial business success with Wireless Sensor Networks
- Committed to serving the R&D community with continued collaboration and reliable wireless R&D platforms and products

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